THE PORT AUTHORITY OF NY & NJ

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**WTCI-639-P**

Cheri
Please make two photocopies, one for me and one for Monica, and then file w/ WTC Fireproofing mat'l.
Thanks.
John

March 23, 2004

John L. Gross, Ph.D., P.E.
Leader, Structures Group
United States Department of Commerce
National Institute of Standards and Technology
Gaithersburg, MD 20899-0001

Dear Dr. Gross:

Following are responses to your questions, which are repeated here in bold italics. The PDF file attached has information previously submitted to NIST as a reference to some of your questions.

***In 1994, the Port Authority's Chemical Division carried out measurements of existing fireproofing on the 23rd and 24th floors of WTC 1. Averages of 6 individual measurements at 16 random locations on each floor (for a total of 32 locations) were reported in a memorandum of 17 March, 1994. While the information reported is useful, additional information is necessary to determine the true statistics of the fireproofing thickness. NIST would like to request the following:***

1. ***Please provide individual measurements, rather than the averages, for all the tested locations.***

The current supervisor and staff of our Chemical/Environmental Testing Laboratory cannot find the supporting information for Mr. Solomon's memo of March 17, 1994. They do, however, state that the procedures similar to those described below in response to question 2 were followed at the time to establish the average thickness data listed in the table.

***Construction audit reports of upgraded fireproofing thickness (floors 92-100 of WTC 1 and floors 77-78, 88-89, 92, 96-97 of WTC 2) indicate that thickness measurements were performed in accordance with ASTM E-605. There is, however, a discrepancy between the required procedure established by ASTM and the Port Authority's audit report data, which states that values were recorded only at the "Bottom of Truss" (see for example, memorandum of November 24, 1999, regarding material applied on 79th floor of WTC 1). Regarding this discrepancy, NIST would like to request the following:***

***2. Please clarify specifically what procedures were used to measure the fireproofing thickness.***

A depth gage is used to determine thickness as follows: A thickness probe made of a needle that extends out along a measured scale is inserted into the fireproof material and stopped at the surface of the steel. The reading of how deep the needle extended into the fireproofing material is shown on the probe and recorded by an inspector. Thickness measurements are taken around the entire member. For the report in question of 11/24/99, 8 discrete measurements were taken to support the result of an average thickness measurement of 2.36 inches.

***3. Please clarify why only data from the "Bottom of Truss" were reported.***

The labeling of "Bottom of Truss" pertains to the location of collection of the physical sample, not field-testing of thickness. A test sample was obtained from the bottom of the truss for density testing, and also represents the location of the pull test. Fireproofing thickness measurements were taken from the truss diagonals as well as the upper and lower truss members, not only at the "Bottom of Truss".

***4. Please provide individual measurements rather than averages.***

The original thickness measurements taken from this report are: 2⅛, 2¼, 2½, 2¾, 1½, 1¾, 1¾, 2¼ inches.

***Finally, in 1995 the Port Authority stated in a memorandum and white paper (memorandum dated August 18, 1995 by Joseph M. Englot) that 1.5 inch thickness of spray-on mineral fiber was required to achieve a 2-hour rating for steel joist trusses in WTC 1 and 2. Based on the 1995 information, guidelines for fireproofing repairs were established in 1999 (buckslip dated March 24, 1999 by Alan L. Reiss).***

***5. Please clarify what is meant by the requirement that 1.5 inches of spray on fireproofing was to be required only on "new construction."***

The term "new construction" means any construction performed in the World Trade Center through a contract or work order that required the application of fireproofing. For example, re-fireproofing floors that have had asbestos mitigation, or otherwise re-fireproofing truss joists where the removal of old ceilings, ducts, light fixtures, and installation of new finishes required significant repair or replacement of the old fireproofing material.

***6. Please clarify the technical basis for permitting tenant spaces where less than a full floor was being renovated to be patched to ¾" of spray-on fireproofing rather than the 1.5" required to achieve a 2-hour rating.***

For questions 5 & 6, the NIST investigative team needs to understand that the guidelines that were developed for upgrading the fireproofing were developed as part of an overall fire safety program that looked at active and passive fire protection along with operating procedures, developed in consultation with outside fire protection experts by the Port Authority's Engineering, Risk Management, and World Trade Departments.

To understand the rationale developed for the fireproofing, one needs to go back to the early 90s. The Port Authority had been relocating tenants in the first zone of One WTC, performing asbestos abatements of the fireproofing on the trusses, re-fireproofing and installing sprinkler loops. The Meridian Plaza fire in Philadelphia caused the Port Authority to accelerate this program and to minimize the number of contiguous floors that were not sprinklered since the benefits of sprinklers were well known and their effectiveness was dramatically shown during the One Meridian Plaza fire.

Subsequent to the 1993 terrorist attack on the World Trade Center, the PA performed a critical self evaluation of the World Trade Center and decided on a number of upgrades including new decentralized fire alarm systems for the complex, fire command consoles in the lobby of each tower staffed around the clock by FDNY certified fire safety directors, continued acceleration of the sprinkler installation within the towers, including the sky lobbies, and increasing the fireproofing requirements for the trusses.

The new fireproofing thickness requirements were incorporated immediately into contracts being written for the abatement and re-fireproofing of floors in the first zone of One WTC and whenever space was demolished and made ready for potential re-leasing. Subsequent to J. Englot's 1995 memo, questions, though, continued to arise regarding whether or not the fireproofing upgrade was required during minor alterations done by tenants. Tenants were required to file Tenant Alteration Applications (TAAs) before any work was performed in their space to make sure the PA could inspect the work. While there were some major alterations, there were many more minor alterations such as the installation of computer and communication network cabling, sprinkler head relocation, adding an air conditioner for a conference room, lighting upgrades, etc. To properly apply the new thickness, at least two sprayed on applications with a sufficient drying time between applications was required. This was not practical in occupied office space where the work consisted of minor alterations such as just installing additional data and voice lines. The implementation of the new 1.5" standard during these minor alterations resulted in situations where ten feet of a single truss, where the ceiling tiles were removed, was upgraded while the balance remained untouched. There was ongoing consideration given to the question of how to properly upgrade the fireproofing if tenant partitions were still standing up to the underside of the slab. As a result, overall benefit of the partial upgrade was brought into question.

Therefore, in consultation with the Office of the Chief Engineer, the 1999 policy was developed to address this issue. It was based on an overall fire-engineering approach, namely:

1. The sprinklerization of tenant spaces.
2. The new redundant decentralized fire alarm systems with consoles located in each tower.
3. Monitoring of the tower fire alarm systems around the clock by FDNY.
4. Certified fire safety directors (whose only responsibility was watching the fire alarm system). Port Authority Police who were stationed at the WTC were trained in structural fire fighting and were immediately notified of any alarm.
5. PA Police had a direct hot line with the Manhattan Fire Dispatchers so they knew what they were responding to, i.e. water flow alarm on a floor or multiple smoke detectors, etc.
6. The removal from the lobbies for tenanted space such as the airline counters and package counters.
7. Periodic testing of the sprinkler system and its components.

There were many occasions where small sections of the original fireproofing had been dislodged by work in the ceiling and it was feasible to patch these areas using a troweled-on patch to the original ¾" thickness, but not to 1.5 inches. Hence, the 1999 policy was developed with the above factors in mind, along with operational test procedures. This provided a process for the phased upgrade of the entire fireproofing system in the World Trade Center in accordance with the Chief Engineer's new requirements, while ensuring the overall safety program was maintained.

These requirements were written into the net lease documents for the World Trade Center to make sure the process continued after the transition from Port Authority operation and management of the WTC. The following is from section 6.2.1:

*1. One World Trade Center and Two World Trade Center Fireproofing – The existing policy of the Port Authority to upgrade steel fireproofing to 1½" thick (based on UL Guideline G508) on the earlier to occur of (i) a full floor becoming vacant, (ii) a full floor being completely renovated or (iii) for any remaining non-compliance office space, within twenty-five (25) years from the Commencement Date, unless the tenant never does a major alteration, shall be applicable to the Lessee, provided the following standards remain in force:*

*a) all floors in One World Trade Center and Two World Trade Center, including Mechanical Equipment Rooms (once the work described in paragraph 7 of Schedule 6.2.3 has been completed) and Sky Lobbies, are sprinkled in conformance with the Port Authority Manual and NFPA 13;*

*b) the Fire Command Centers in the lobby shall be (i) staffed with a New York City Certified "Fire Safety Director" at all times, and (ii) a total video surveillance system is installed and operating and is being monitored at all times, then the sprinkler plan may exclude the*

*310 level of both One World Trade Center and Two World Trade Center. There will be no other permanent or temporary uses within the lobby, other than (i) the Command Center(s), visitors' desk(s), and mail boxes, provided each such area contains steel frames with marble fronts and composite/laminate tops, and (ii) temporary holiday displays composed of non-flammable materials;*

c) *the Lessee continues the current programs and implements additional programs as necessary to ensure the inspection, testing, and maintenance procedures of and for the sprinkler systems and the components thereof, which include, but are not limited to, the water supply, fire pumps, gravity tanks, piping and valving.*

*These programs shall be designed to comply with the intent of NFPA 25 and the other requirements contained in the Port Authority Manual; and*

d) *when the Lessee is performing the testing of the sprinkler system's water flow and alarm transmission, the specific system pressure indicated at the gage downstream of the pressure-reducing valve shall be recorded at the time of such testing, to ensure conformance with the minimums/maximums indicated on the valves.*

*If the practices described in clauses (a) through (d) above are not adhered to, the Lessee shall immediately begin such fireproofing, even if such work causes the Lessee to relocate the affected Space Tenants.*

I hope this answers your questions. Please call or reply otherwise if you need further information.

Very truly yours,

Francis J. Lombardi, PE
Chief Engineer

Attachment

PA memoranda.pdf

**THE PORT AUTHORITY OF NY AND NJ MEMORANDUM**

**TO:** E. Ramabhushanam
**FROM:** S.M. Solomon
**DATE:** March 17. 1994
**SUBJECT:** WTC Existing Fireproofing

**REFERENCE:**

**COPY TO:** V. Berndt, C. Bognacki, Eng. Files

As requested, the Chemical Division performed numerous thickness measurements on existing fireproofing located on the 23rd and 24th floors of the WTC North.

Damaged and/or absent fireproofed areas on the 23rd Floor were repaired with patch material; These areas were not measured. Truss members located adjacent to the outside walls (within 3 feet) are devoid of fireproofing material. Visual inspection of the truss members on the 24th floor was not possible, as this area still has a lowered ceiling in place. Tests were taken through areas where ceiling tiles were removed. Thickness readings were taken on 16 random truss members on each floor. Measurements were taken from both flanges and webs of the truss member.

At each of these locations, a total of six individual measurements were made and averaged. These mini averages are listed on the attached table along with a total average, standard deviation, high value and low value for each floor.

S.M. Solomon
Chief of Chemical/
Environmental Testing

RG

## *NUMBER TWO WTC*
## *EXISTING FIREPROOFING THICKNESS*

| | 23rd Floor | 24th Floor |
|---|---|---|
| Readings, inches: | 0.60 | 0.76 |
| | 0.53 | 0.60 |
| | 0.70 | 0.90 |
| | 0.76 | 0.72 |
| | 0.88 | 0.64 |
| | 0.89 | 0.80 |
| | 0.83 | 0.68 |
| | 1.17 | 0.65 |
| | 0.88 | 0.67 |
| | 0.71 | 0.77 |
| | 0.82 | 0.96 |
| | 0.52 | 0.66 |
| | 0.69 | 0.85 |
| | 0.62 | 1.11 |
| | 0.64 | 0.95 |
| | 0.52 | 0.58 |
| Average | 0.73 | 0.76 |
| Standard Deviation | 0.14 | 0.15 |
| High | 1.17 | 1.11 |
| Low | 0.52 | 0.56 |

**THE PORT AUTHORITY OF NY AND NJ** **MEMORANDUM**

| | |
|---|---|
| **TO:** | Edward McGinley |
| **FROM:** | Dorian Bailey |
| **DATE:** | November 24, 1999 |
| **SUBJECT:** | World Trade Center: Test of Fire Resistive Material<br>Contract WTC - 697.00 W.O. #8934 Charge #W02-600.216 |
| **COPY TO:** | C. Bognacki, J. Bullard, P. Ortiz, J. Shanahan, M.Young, E.F. |

As requested, the Materials Engineering Division has tested the application of the sprayed-on fireproofing, CAFCO Blaze-Shield II for conformance to Port Authority specifications. The material was applied at the 79th floor of WTC #1.

The tests were performed in accordance with ASTM E-605, "Thickness and Density" and ASTM E-736 "Adhesion/Cohesion" of Sprayed Fire Resistive Materials Applied to Structural Steel Members".

The results are as follows:

| | Density lb./cu. ft. | Adhesion/ Cohesion lb./sq. ft. | Thickness Inches |
|---|---|---|---|
| *Minimum Requirements* | *15.00* | *150* | *1.50* |
| **TEST AREA #1**<br>1WTC 79th Floor<br>Truss 433 West<br>Bottom of truss | 16.64 | 333 | 2.36 |

The test results indicate that the applied fireproof material, CAFCO Blaze-Shield II meets Port Authority specifications. Therefore the Materials Engineering Division recommends the acceptance of the fireproofing material.

Dorian Bailey
Staff Services Engineer

c:\angelos\fireproofing\1wtc79

THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

CHIEF ENGINEER'S OFFICE
P.A. OF N.Y. & N.J.
REC'D

BUCKSLIP

1999 MAR 25 PM 3:28

TO: John Castaldo, Kent Piatt
FROM: Alan L. Reiss
DATE: March 24, 1999
SUBJECT: World Trade Center Fireproofing Guidelines For Tenant Spaces

COPY TO: E. McGinley, T. Kobel, F. Lombardi J. Richardson, J. Napolitano, R. Rafferty, L. Menno, E. Moscovitz, C. Nanninga, N. Seliga, T. Stam

In order to establish clear and consistent guidelines regarding fireproofing repairs, replacement, and upgrades at the World Trade Center Towers, the following guidelines have been established with the concurrence of the Chief Engineer.

1) Full floors being demolished for new construction or renovation shall have the fireproofing on trusses checked and upgraded if it has not already been done to the attached 1995 Engineering Department Engineered Solutions Standard. Adequate time must be allowed in any schedule to accommodate this work, typically two weeks. This work may be performed by either the tenant or us but is a landlord obligation and reimbursable to the tenant (typically $5/sq. ft.) if the work is performed by the tenant. Refireproofing requires removal of existing material to insure adequate bonding and is subject to a controlled inspection.

2) Tenant spaces that are less than a full floor, undergoing either new construction or renovation, need only meet the original construction standard. Fireproofing shall be inspected and patched as required to the greater of ¼" or to match existing (it may already have been upgraded to the Engineered Solutions Standard.)

3) On a new lease, trusses requiring patching at the time of tender of the space are a landlord obligation, however, we normally will reimburse fair and reasonable costs if performed by the tenant after authorization. For existing tenant space being renovated, careful judgement should be used to determine if the need for the work arose as a result of a tenant action, i.e. previous construction work, or our obligation because of our work over the years in the ceiling. Any recommendation should be discussed with project and property management prior to being discussed with the tenant.

| | | | | | | |
|---|---|---|---|---|---|---|
| AT | AF | BF | CJL | RP | SB | |
| DD | MAR 26 1999 | | | | | MA |
| CK | | | | | | RS |
| FILE | C. JOHN LIN MANAGER O.A.D. | | | | | IR |
| POST | | | | | | RTN |

Alan L. Reiss
Director
World Trade Department

THE PORT AUTHORITY OF NEW YORK & NEW JERSEY

MEMORANDUM

TO: Peter Sweeney, Engineering Program Manager
FROM: Joseph M. Englot
DATE: August 18, 1995
SUBJECT: **STEEL JOIST SPRAY-ON REQUIREMENTS FOR NEW CONSTRUCTION IN WORLD TRADE CENTER TOWERS**

COPY TO: R. Davidson, J. Lin, F. Lombardi, E. Ramabhushanam, O. Suros

Attached is a white paper summarizing a study to determine the spray-on thickness required to achieve the required two hour rating for steel joist trusses in the towers of the World Trade Center. This is intended for any new construction for which the Engineering Department is engineer-of-record. It concludes that 1-1/2 inches of spray-on mineral fiber is sufficient when applied directly to chords and web members.

Joseph M. Englot, P.E.
Chief Structural Engineer

JME:ng

Attachment

## FIREPROOFING REQUIREMENTS FOR WORLD TRADE CENTER TENANT FLOOR JOIST CONSTRUCTION THAT REQUIRES INSTALLATION DUE TO ASBESTOS REMOVAL OR LOCAL REMOVAL TO FACILITATE CONSTRUCTION

This serves as a basis for determining the minimum requirements for installing sprayed mineral fiber fireproofing on the steel floor joist trusses supporting typical tenant floor areas within the towers of the World Trade Center. Its purpose is to establish requirements for new construction that meet local codes and ordinances.

The technical basis for the fireproofing requirement is Design No. G805 in the Fire Resistance Directory (BXRH) Published by Underwriters Laboratories. This UL design is based upon fire tests conducted as per ASTM E-119 which is a basic Reference Standard (No. RS5-2) in the New York City Building Code for structural members and assemblies. Reference standard RS5-1F, "Methods of Analytical Determination of Fire Resistance of Load Bearing Steel Truss Assemblies", is not applied since it is intended for large trusses (i.e., deep trusses), too large to fit in the fire test compartments. Since there is a wealth of fire tests on steel joists which approximate the ones used in the World Trade Center, joist test results are interpreted to arrive at an appropriate spray-on protection thickness.

There are various parameters in the G805 design which have to be interpreted or approximated in the case of World Trade Center construction. Each parameter will be discussed individually.

### Joist Spacing

G805: 48 inch and 66 inch spacing.
Actual: Double joist system - average joist spacing is 40 inches (spacing alternates between 8 inches and 72 inches). Conservatively, use values for 66 inches since actual spacing is not uniform.

### Metal Deck Protection

G805: Values tabulated with or without spray-on applied to bottom of metal deck.
Actual: Use values without spray-on applied to deck. Spray-on is only used in the World Trade Center below trench headers. Follow design values without protected deck.

### Concrete Topping

G805: Values tabulated for lightweight concrete, 117 pcf unit weight, 3500 psi compressive strength and a thickness of topping over the metal deck of 3-7/8 inches to achieve a 2 hour rating.
Actual: Lightweight concrete, 110 pcf unit weight, 3000 psi compressive strength and a thickness of topping over the metal deck of 4 inches. The actual is judged equivalent to the G805 design for 2 hour rating.

### Wire Mesh Location

G805: Provides a thickness of concrete from the top plane of the metal deck to the wire fabric of 1-1/4 inches for a 2 hour rating with 1-5/16 inch deep steel form unit.
Actual: Has two layers of wire mesh. Thickness from top plane of 1-1/2 inch metal deck to center of wire mesh layers is 1.22 inches. Where rebar is used instead of wire mesh, 1-1/4 inch thickness

is provided. This is judged to be equivalent to the G805 design for 2 hour rating.

Steel Joist Parameters

G805: Composite steel joist with a minimum area of steel (double angles) for top and bottom chords (each) of 0.708 sq. inches and minimum steel area of web members of 0.442 sq. inches in conjunction with the "thinner" layer of spray-on (1-1/2 inches) applied directly to the joist without lath.
Actual: Minimum area of chords is 0.813 sq. inches and the minimum area of web steel is 0.665 sq. inches with composite behavior. 1-1/2 inches applied directly to the joist steel yields a two hour assembly rating whether restrained or unrestrained.

Ceiling

G805: A ceiling is not relied upon for fire protection in the design.
Actual: All occupied areas in the World Trade Center have ceilings and they will add to the fire rating of the floor system, however, a stringent study of what rating values could be achieved for existing types of ceilings is beyond the scope of this study.

Conclusion

It is concluded that a two hour fire rating for the steel floor joist trusses can be achieved by applying a 1-1/2 inch thickness of spray-on mineral fiber fire protection material directly to the steel truss chords and webs. The value of the ceiling as a fire protection element is not relied upon to achieve this fire rating.
Attachments:

1. Excerpted pages from N.Y.C. Building Code.
2 G805 Design from U.L. Directory